Registration of 'CP 05-1526' Sugarcane

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ABSTRACT

'CP 05-1526' (Reg. No. CV-155, PI 667554) sugarcane (a complex hybrid of *Saccharum* spp.) was developed through cooperative research conducted by the USDA-ARS, the University of Florida, and the Florida Sugar Cane League, Inc., and released to growers for organic (muck) and sand soils in Florida in October 2012. CP 05-1526 was selected from the cross CP 98-1029 × CP 88-1162 made at Canal Point, FL in December 2002. The female parent (CP 98-1029) is a sugarcane cultivar released for commercial use in Florida in 2005. The male parent (CP 88-1162) is an experimental clone of the Canal Point sugarcane breeding and cultivar selection program. CP 05-1526 was released because of its high cane and sucrose yields and acceptable commercial recoverable sucrose on both muck and sand soils, and its acceptable levels of resistance to brown rust (caused by *Puccinia melanocephala* H. & P. Sydow), orange rust (caused by *Puccinia kuehnii* E.J. Butler), leaf scald (caused by *Xanthomonas albilineans* Ashby, Dowson), *Sugarcane mosaic virus* strain E (mosaic), ratoon stunt (caused by *Leifsonia xyli* subsp. x*yli* Evtsuhenko et al.), and smut (caused by *Ustilago scitaminea* H. & P. Sydow) in Florida. CP 05-1526 has an intermediate level of freeze tolerance based on its relative rank of 11 in 22 genotypes tested and analyzed for temporal sucrose deterioration under field conditions.

CP 05-1526 (Reg. No. CV-155, PI 667554) is a sugarcane (a complex hybrid of *Saccharum* spp.) derivative of a long-term recurrent selection program conducted through cooperative research of the USDA-ARS, the University of Florida, and the Florida Sugar Cane League, Inc. It was released in Florida on 16 Oct. 2012. Modern sugarcane cultivars, such as CP 05-1526, are allopolyploid (with aneuploidy) hybrids, and in the mainland USA, they can be traced back to 17 founder clones (Deren, 1995). These founders were used in *S. officinarum* × *S. spontaneum* crosses, and the F_1 hybrids were backcrossed to the *S. officinarum* to recover a high sucrose concentration (Roach, 1972; Sreenivasan et al., 1987). The modern sugarcane cultivars represent advanced generations of long-term breeding that began with these backcrosses.

Sugarcane was grown on 160,943 ha in Florida in 2011 (Rice et al., 2012). Approximately 80% of these sugarcane hectares were organic (muck) soils and 20% were sand soils. The primary objective of the Canal Point (CP) sugarcane breeding and cultivar selection program (CP program) is to develop high-yielding cultivars with enhanced resistance or tolerance to biotic and abiotic stresses for muck and sand soils in Florida (Zhao et al., 2010). CP 05-1526 was released because of its high yields of cane and sucrose and acceptable commercial recoverable sucrose (CRS) on muck and sand soils in Florida, and its acceptable or moderate resistance to brown rust (caused by *Puccinia melanocephala* H. & P. Sydow), orange rust (caused by *Puccinia kuehnii* E.J. Butler), smut (caused by *Ustilago scitaminea* H. & P. Sydow), leaf scald (caused by *Xanthomonas albilineans* Ashby, Dowson), and ratoon stunt (caused by *Leifsonia xyli* subsp. *xyli* Evtsuhenko et al.) in Florida. CP 05-1526 was the 526th (recorded 1526) selection assigned in the year 2005 (05) in the first clonal selection stage and was named according to routine CP naming protocol. Selection numbers in the range from 1000 to 2999 are reserved for genotypes selected from the CP program and bred for the Florida industry.

CP 05-1526 was selected from the cross CP 98-1029 × CP 88-1162 made at Canal Point, FL in December 2002. The female parent (CP 98-1029) was released in the fall of 2005 (Edmé et al., 2006). The male parent (CP 88-1162) was not released for commercial production due to undesirable

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Abbreviations: CP, Canal Point; CRS, commercial recoverable sucrose; TRS, theoretical recoverable sucrose; TVD, top visible dewlap.

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yield potential but was maintained in the parental pool of the CP program.

Methods

Early Selection Stages

CP 05-1526 was selected through the standard selection procedures (Table 1) of the CP program as described by Tai and Miller (1989). The cross CP 98-1029 × CP 88-1162, numbered X02-1405, was made at Canal Point in December 2002. The F_1 seed was planted in flats in a greenhouse early in 2004, and the seedling plants were transplanted to the field in May 2004 at Canal Point. One stalk from the stool that was to become CP 05-1526 was selected from the Seedling stage and advanced to stage 1 in January 2005 with 12,124 other unreplicated selections. From this stage onward, the CP program propagates genotypes clonally. Stage-1 plots comprised 0.9-m long single rows separated by 1.5-m alleys. As in all other selection stages, row spacing in stage 1 was 1.5 m. Selection in seedling stage and stage 1 was visual, with emphasis on plant vigor and resistance to natural infections of brown rust, smut, mosaic, and leaf scald. Eight stalks of each selected genotype in stage 1 were cut to plant the stage-2 tests in mid-November 2005.

CP 05-1526 was planted in stage 2 at Canal Point in November 2005 with 1319 other unreplicated genotypes (10.9% of selection from stage 1). Stage-2 plots consisted of two rows that were 4.5 m in length with 1.5 m spacing between rows. Plots were arranged in the stage-2 field using a standard means (Glaz et al., 2013). 'CP 72-2086' (Miller et al., 1984), 'CP 78-1628' (Tai et al., 1991), and 'CP 89-2143' (Glaz et al., 2000) were the reference cultivars in stage 2. These reference cultivar plots were replicated 18 times and randomly distributed in the stage-2 field. Visual ratings were made in stage 2 on growth habit, agronomic traits, and natural infection of diseases. Generally, highly recumbent genotypes, genotypes with protruding buds, and genotypes with many broken stalks were not selected.

Stalks in each plot were counted in stage 2 in August 2006, and these numbers were used to estimate the population of stalks per hectare. In October 2006, 10-stalk samples were collected from each plot and weighed. Cane yield (*C*) was estimated as the product of stalk weight by stalk number:

$$C\ (\text{Mg ha}^{-1}) = \text{stalk weight (kg stalk}^{-1}) \times \text{stalk number (stalks ha}^{-1}) \div 1000$$

All 10-stalk samples were weighed and immediately milled to extract juice and to determine theoretical recoverable sucrose (TRS) (Legendre, 1992). Fiber was estimated as 10% for all genotypes in stages 2 and 3. All values of TRS were multiplied by 0.86 to approximate CRS based on a liquidation factor of 0.83 to 0.90 reported by Legendre (1992). This liquidation factor is also used by commercial mills in Louisiana to convert TRS to CRS. Sucrose yield (*S*) was calculated as:

$$S\ (\text{Mg ha}^{-1}) = C\ (\text{Mg ha}^{-1}) \times \text{CRS (kg Mg}^{-1}) \div 1000$$

The economic index (profitability) was calculated based on a procedure that integrated sucrose content with costs of harvesting, hauling, and milling the cane in Florida (Deren et al., 1995). The major selection criteria in stage 2 and later in stages 3 and 4 were profitability, cane yield, sucrose yield, and resistance to diseases (primarily brown rust, mosaic, smut, and leaf scald). In 2007, orange rust was found in South Florida, and resistance to orange rust was included as another selection criterion.

Yield Trials in Commercial Fields

From stage 2, 135 genotypes (10.2% of the selections of stage 2) were advanced to stage 3 in November and December 2006. Stage-3 genotypes and three reference cultivars (CP 72-2086, CP 78-1628, and CP 89-2143) were planted in yield trials in commercial fields at four grower farms representative of the Florida sugarcane industry. The farms of A. Duda & Sons, Inc. (26°35.93′ N, 80°37.81′ W), Okeelanta Corporation (26°34.35′ N, 80°49.72′ W), and Sugar Farms Cooperative North–Osceola Region (26°50.53′ N, 80°31.93′ W) had muck soils, and the farm of Hilliard Brothers of Florida Ltd. (26°42.14′ N, 81°2.31′ W) had a sand soil. All four trials had the same plot size (two rows, 3 m wide by 4.5 m long) with two replications of each genotype planted in a randomized complete block design with a field plot arrangement as described by Glaz et al. (2013). Stalk counts were made in July through September 2007, and stalk weight data were collected in the plant-cane (October 2007 and January 2008) and first-ratoon (October 2008) crops. Estimates of cane and sucrose yields and profitability were determined as described in stage 2. Based on these estimates as well as on resistance to brown rust by natural infection and resistance to leaf scald and mosaic by artificial inoculation (Glaz et al., 2013) and natural

Table 1. Summary of the decision process leading to the release of sugarcane cultivar CP 05-1526 in Florida.

Year	Month	Stage and selection decision	Number of genotypes in stage	Locations
2002	December	Cross made at USDA-ARS Sugarcane Field Station	—	Canal Point, FL
2004	May	Germinated true seed transplanted into field (seedlings)	100,000	Canal Point, FL
2005	January	Advanced from plant-cane seedlings to stage 1	12,125	Canal Point, FL
2005	November	Advanced from plant-cane stage 1 to stage 2	1,320	Canal Point, FL
2006	November– December	Advanced from plant-cane stage 2 to stage 3	135	Four farms in FL
2008–2009	November– December	Advanced from first-ratoon stage 3 to stage 4	13	Ten farms in FL
2012	October	Cultivar release	1	

infection, CP 05-1526 was among the 13 genotypes selected for advancement from stage 3 to stage 4 in November 2008.

CP 05-1526 and the other 12 stage-4 selections were planted in yield trials within commercial fields at eight grower farms in November and December 2008 and two grower farms in November 2009. The 2008 trial sites included those described for stage 3 plus four more locations. These locations included Knight Management, Inc. (26°38.53′ N, 80°27.21′ W) and Wedgworth Farms, Inc. (26°40.73′ N, 80°34.37′ W), both of which have muck soils, as well as Lykes Brothers, Inc. (26°53.08′ N, 81°8.41′ W) and Townsite Farm of United States Sugar Corporation (26°44.37′ N, 80°58.95′ W), both with sand soils. Two stage-4 muck-soil trial sites were planted in 2009 at Eastgate Farms, Inc. (26°47.67′ N, 80°39.97′ W) and Okeelanta Corporation (26°39.67′ N, 80°73.18′ W). The primary reference cultivars in trials planted on muck soils were CP 72-2086 and CP 89-2143, and the primary reference cultivars in the trials planted on sand soils were CP 78-1628 and CP 89-2143. These are the most widely grown sugarcane cultivars on muck and sand soils in Florida, respectively (Rice et al., 2012). All trials were planted in randomized complete block designs with six replications in plots three rows wide and 10.5 m long. Alleys of 1.5 m separated the plots. The experimental fields at all locations were 9 m (two plots) wide and 576 m (48 plots) long. Cane tonnage was estimated based on stalk counts and mean stalk weight as described above for the plant-cane (2009), first-ratoon (2010), and second-ratoon (2011) crops. Stalk weight and CRS were estimated as described for stage 2 from a 10-stalk sample collected in the middle row of each plot from October through March of 2009–10 (plant cane), 2010–11 (first ratoon), and 2011–12 (second ratoon). When calculating CRS in stage 4, estimated fiber concentration was used in the calculations as described by Legendre (1992). The estimation of fiber concentration is described below.

Seventeen samples of CP 05-1526 were processed for analysis of fiber concentration over the 3-yr period in stage 4. Each sample consisted of five border-row mature stalks (so as not to affect rows used for yield estimation). After stripping the leaves, stalks were shredded through a Jeffco cutter-grinder (Jeffries Brothers, Ltd.). A 400-g subsample was collected and pressed at 138 MPa for 30 s to extract juice. Degrees Brix of juice was measured with a handheld digital refractometer (Spectrum Technologies). The pressed fiber samples were weighed, crumbled, placed in paper bags, and dried at 60°C to a constant weight. Fiber concentrations were calculated as described by Tanimoto (1964). Samples of a reference cultivar from the same field were processed on all dates when fiber samples of CP 05-1526 were processed. All fiber concentrations calculated on a given day were adjusted and corrected based on the historic fiber concentration of the reference cultivar well known in Florida. For example, the historic fiber concentration of CP 78-1628 was 103.9 g kg^{-1} cane (Tai et al., 1991). If the estimated fiber concentration of CP 78-1628 was 100.0 g kg^{-1} on the day when a set of samples for CP 05-1526 was processed, a correction factor (1.039) was obtained by dividing the historic fiber concentration by the estimated fiber concentration (i.e., 103.9/100.0). Then the estimated fiber concentration of CP 05-1526 would have been multiplied by the correction factor. The mean of corrected values for fiber concentration of CP 05-1526 was used each year in the formula reported by Legendre (1992) for calculating its CRS.

For evaluation of yield traits, including stalk weight, cane yield, CRS, sucrose yield, and profitability, CP 05-1526 was assessed in 28 harvests of replicated yield trials, including 10 plant-cane, 10 first-ratoon, and 8 second-ratoon crops, at 10 locations with 12 other stage-4 genotypes and the 3 reference cultivars in Florida during three crop cycles (plant cane, first ratoon, and second ratoon) in 2009–11. Nineteen of these harvests were from trials planted on muck soils at seven locations, and nine of these harvests were from trials planted on sand soils at three locations.

Agronomic and Botanical Descriptions

Data for the agronomic and botanical descriptions were recorded from 10 stalks in the plant-cane crop sampled on 1 and 2 Aug. 2012 from a field with Torry muck soil at Eastgate Farms, Inc. near Pahokee, FL for CP 05-1526 and CP 89-2143 and from a Margate/Oldsmar sand soil at the United States Sugar Corporation's Townsite Farm near Clewiston, FL for CP 78-1628. Stalks were sampled from the inner rows and the agronomic and botanical characters were described according to Artschwager and Brandes (1958). Colors were characterized according to color charts for plant tissues (Munsell Color Co., 1977). Stalk characteristics of CP 05-1526 were compared with those of CP 89-2143 and/or CP 78-1628. All cultivars were sampled and described on the same date, approximately 270 d after they were planted.

Molecular Characterization

Six pairs of microsatellite primers (Table 2), developed by several research institutes through the International Consortium for Sugarcane Biotechnology (Glynn et al., 2009), were used to generate a genetic fingerprint for CP 05-1526. The genetic fingerprint results of CP 05-1526 were compared with those of cultivars CP 72-2086, CP 78-1628, CP 80-1743 (Deren et al., 1991), CP 84-1198

Table 2. Size range of base pair and number of fragments generated by each of six microsatellite primer pairs from sugarcane cultivars CP 72-2086, CP 78-1628, CP 80-1743, CP 84-1198, CP 89-2143, and CP 05-1526.

Primer name	Size range of fragments	Number of fragments	
		Total (all six cultivars)	From CP 05-1526 total (unique)
	bp		
SMC222CG	167–214	3	3
SMC221MS	122–155	4	3
SMC179SA	115–219	14	6 (2)
SMC1493CL	105–169	12	7 (1)
mSSCIR14	221–258	6	3
mSSCIR53	178–246	6	3 (1)

(Glaz et al., 1994), and CP 89-2143. Reaction conditions of polymerase chain reaction were similar to those previously described by Glynn et al. (2009) with some modifications of the thermocycling. Briefly, the thermocycling consisted of 95°C for 3 min, 94°C for 45 s, 6 cycles of 68°C for 5 min (decreasing by 2°C per cycle), 72°C for 1 min, 94°C for 45 s, 8 cycles of 58°C for 2 min (decreasing by 1°C per cycle), 72°C for 30 s, and 24 cycles of 94°C for 45 s, 50°C for 2 min, and 72°C for 30 s followed by a final extension of 72°C for 7 min. CP 05-1526 was also tested for *Bru*1, a major gene for resistance to brown rust of sugarcane according to Asnaghi et al. (2004).

Disease Resistance

Screening of CP 05-1526 for disease reactions was conducted by inoculation testing and/or monitoring for natural infection to smut, leaf scald, brown rust, orange rust, mosaic, *Sugarcane yellow leaf virus*, eye spot [caused by *Bipolaris sacchari* (E.J. Butler)], and ratoon stunt in greenhouses and/or under field conditions using the standard methods in the CP program (Comstock et al., 1999; Sood et al., 2009; Glaz et al., 2013). The rating scale for brown and orange rusts consisted of five classes: 0 (resistant), 1 (moderately resistant), 2 (moderately susceptible), 3 (susceptible), and 4 (highly susceptible) determined primarily on the basis of size and number of uredia (Sood et al., 2009; Zhao et al., 2011). Inoculation tests for susceptibilities of CP 05-1526 were based on the percentage of infected plants for mosaic and leaf scald, the percentage of plants with sori for smut, and the number of colonized vascular bundles for ratoon stunt. The susceptibility of CP 05-1526 to smut was compared with that of cultivars CP 73-1547 (Miller et al., 1982) and CP 78-1628, and susceptibilities to leaf scald and mosaic were compared with those of CP 80-1743 and CP 72-1628, respectively. Comparisons were made with these varieties because their susceptibilities are at the upper limits of acceptability for commercial sugarcane production in Florida. Inoculation tests to compare ratoon stunt susceptibility of CP 05-1526 with that of CP 72-1210 (Miller et al., 1981) were conducted from 2006 through 2008. The number of colonized vascular bundles of CP 05-1526 and CP 80-1827 (Glaz et al., 1990) were also compared in 2007.

Freeze Tolerance

To assess freeze tolerance, all stage-4 genotypes were subjected to freezing temperatures in field experiments established at the Hague Farm (29°45.0′ N, 82°25.5′ W) of the Florida Institute of Food and Agricultural Sciences, University of Florida, Hague, near Gainesville, FL. CP 05-1526, along with 18 other genotypes and three reference cultivars (CP 72-2086, CP 78-1628, and CP 89-2143) were planted on 26 Oct. 2010 in a randomized complete block design with four replications in single-row plots 2.7 m long and 1.5 m apart with 2.4-m alleys between replications. Five mature stalks from each plot were collected on 9 and 30 Nov. 2011, on 6 and 25 Jan. 2012, and on 9 Feb. 2012 for analyses of sucrose concentrations. The low temperatures of the five sampling dates were >0, –2.2 (for 6 h), –2.8 to –7.8 (8 h), –2.8 (3 h), and –1.7°C (2 h), respectively. The stalk samples were transported to Canal Point for milling and analysis of sucrose concentration from extracted juice. Freeze tolerance assessment was based on temporal decline (deterioration) of the percentage sucrose after exposure of mature plants to freezing temperatures in the field.

Statistical Analyses

Analyses of yield components for the stage-4 tests were performed with PROC MIXED of SAS (SAS Institute, 2003). Data were analyzed for each crop cycle separately and with the combined data of the plant-cane, first-ratoon, and second-ratoon crops. Within-year analyses used a mixed model with genotypes considered as fixed effects and locations and replications within locations considered as random effects. Across-year analyses used a mixed model with genotypes and crop cycles as fixed effects and locations and replications within locations considered as random effects. Differences among genotypes for stalk weight, cane yield, CRS, sucrose yield, and economic index were declared significant based on the LSD test procedure at $P = 0.05$. For freeze-tolerance evaluation, the data of sucrose concentration were analyzed according to an additive main effect and multiplicative interaction (AMMI) model and the adjusted values were used to calculate the relative changes in percent sucrose (Edmé and Glaz, 2013).

Characteristics

Yield Performance

The mean cane yield of CP 05-1526 on muck soils, averaged across the 19 harvests was 37.6 and 16.4% higher ($P < 0.05$) than the mean cane yields of CP 72-2086 and CP 89-2143, respectively (Table 3). The CRS of CP 05-1526 was 2.7 and 3.9% ($P < 0.05$) lower, but the sucrose yield was 31.9 and 11.2% higher ($P < 0.05$) than those of CP 72-2086 and CP 89-2143, respectively. The economic index of CP 05-1526 was significantly greater (30.6%, $P < 0.05$) than that of CP 72-2086 but did not differ significantly from that of CP 89-2143.

The mean cane yield of CP 05-1526 on sand soils was 25.1% higher than that of CP 78-1628, the commercial check for sand soils in Florida, and 11.2% higher than that of CP 89-2143 (Table 4). CP 05-1526 had 2.1 and 5.9% lower CRS than CP 78-1628 and CP 89-2143 but 22.8 and 2.8% higher sucrose yields. The economic index for CP 05-1526 was 26.3% higher than that of CP 78-1628, but 3.6% lower than that of CP 89-2143 (Table 4). The only statistical difference ($P < 0.05$) was detected in the CRS between CP 89-2143 and CP 05-1526 on sand soils (Table 4).

The mean stalk weight of CP 05-1526 on muck soils across plant-cane, first-ratoon, and second-ratoon crops did not differ from that of CP 72-2086 but was 9.3% greater ($P < 0.05$) than the stalk weight of CP 89-2143 (Table 3). On sand soils, the stalk weight of CP 05-1526 was 34.8 and 18.8% greater ($P < 0.01$) than the stalk weights of CP 78-1628 and CP 89-2143, respectively (Table 4). The number of mature stalks of CP 05-1526 on muck soils was 32.1 and 5.6% higher than that of CP 72-2086 and CP 89-2143; and

Table 3. Stalk weights, cane yields, commercial recoverable sucrose values, sucrose yields, and economic indices of CP 05-1526 and two reference cultivars, CP 72-2086 and CP 89-2143, planted on muck soils at seven locations in the plant-cane, first-ratoon, and second-ratoon crops.

Cultivar	Crop cycle			
	Plant cane	First ratoon	Second ratoon	Mean
	Stalk weight (kg stalk^{-1})			
CP 05-1526	1.99 a†	1.53 a	1.38 a	1.64 a
CP 72-2086	1.89 a	1.52 a	1.25 a	1.56 ab
CP 89-2143	1.72 b	1.45 a	1.28 a	1.50 b
	Cane yield (Mg ha^{-1})			
CP 05-1526	190.0 a	161.7 a	110.4 a	154.0 a
CP 72-2086	144.4 b	117.3 c	73.9 b	111.9 c
CP 89-2143	150.7 b	144.2 b	102.0 a	132.3 b
	Commercial recoverable sucrose (kg Mg^{-1})			
CP 05-1526	113.6 b	116.4 b	113.3 a	114.5 b
CP 72-2086	120.4 a	121.9 a	110.9 a	117.7 a
CP 89-2143	119.4 a	123.0 a	114.9 a	119.1 a
	Sucrose yield (Mg ha^{-1})			
CP 05-1526	21.64 a	18.91 a	12.68 a	17.73 a
CP 72-2086	17.50 b	14.43 b	7.88 b	13.44 c
CP 89-2143	18.08 b	17.89 a	11.85 a	15.94 b
	Economic index ($ ha^{-1})			
CP 05-1526	3861 a	3292 a	1857 a	3003 a
CP 72-2086	3202 b	2561 b	1134 b	2299 b
CP 89-2143	3298 b	3259 a	1743 a	2767 a
Locations	7	7	5‡	

†For each characteristic, means within a column followed by the same letter are not significantly different based on LSD test at $P = 0.05$.

‡Yield parameters of the second-ratoon crop for the 2009 planted two trials were not available on the release date.

Table 4. Stalk weights, cane yields, commercial recoverable sucrose values, sucrose yields, and economic indices of CP 05-1526 and two reference cultivars, CP 78-1628 and CP 89-2143, planted on sand soils at three locations in the plant-cane, first-ratoon, and second-ratoon crops.

Cultivar	Crop cycle			
	Plant cane	First ratoon	Second ratoon	Mean
	Stalk weight (kg stalk^{-1})			
CP 05-1526	1.53 a†	1.14 a	0.92 a	1.20 a
CP 78-1628	1.17 b	0.83 c	0.67 b	0.89 c
CP 89-2143	1.28 b	1.01 b	0.74 b	1.01 b
	Cane yield (Mg ha^{-1})			
CP 05-1526	133.3 a	115.1 a	88.1 a	112.2 a
CP 78-1628	103.0 a	95.2 a	71.0 a	89.7 a
CP 89-2143	117.3 a	107.5 a	77.5 a	100.9 a
	Commercial recoverable sucrose (kg Mg^{-1})			
CP 05-1526	118.0 b	121.4 b	103.4 a	114.4 b
CP 78-1628	118.9 b	124.4 b	107.5 a	116.9 ab
CP 89-2143	125.6 a	130.5 a	108.8 a	121.6 a
	Sucrose yield (Mg ha^{-1})			
CP 05-1526	15.67 a	13.82 a	9.05 a	12.85 a
CP 78-1628	12.15 a	11.55 a	7.66 a	10.46 a
CP 89-2143	14.86 a	13.96 a	8.59 a	12.49 a
	Economic index ($ ha^{-1})			
CP 05-1526	2723 a	2392 ab	1101 a	2072 a
CP 78-1628	1990 a	1975 b	958 a	1641 a
CP 89-2143	2747 a	2582 a	1111 a	2149 a

†For each characteristic, means within a column followed by the same letter are not significantly different based on LSD test at $P = 0.05$.

the number of stalks for CP 05-1526 on sand soils was 7.9% less than the corresponding number for CP 78-1628. CP 05-1526 had a fiber concentration of 115.2 g kg^{-1} (or 11.52%) compared with 89.7, 103.9, and 98.5 g kg^{-1} for CP 72-2086, CP 78-1628, and CP 89-2143, respectively.

Agronomic and Botanical Descriptions

Agronomic and botanical characteristics of CP 05-1526 were compared with those of CP 89-2143 and/or CP 78-1628 (Table 5). Stalks of CP 05-1526 were 30% taller than those of CP 89-2143, measured from the ground to the top visible dewlap (TVD), and the internodes of CP 05-1526 were 26% longer than those of CP 89-2143 on the muck soil. The stalk diameters of CP 05-1526 and CP 78-1628 were similar at the middle portions of stalks, but the diameter of CP 05-1526 was less than that of CP 89-2143, and CP 05-1526 had a larger stalk diameter at upper portion of stalks compared with the two reference cultivars (Table 5). Some differences were also observed between CP 05-1526 and the two reference cultivars in leaf sheath pubescence, leaf size, stalk bud shape and size, and other botanical characteristics listed in Table 5.

Additionally, the portions of CP 05-1526 stalks that were not covered by leaf sheaths had a heavy black wax layer. Beneath the wax layer, the uncovered stalk portions of CP 05-1526 were green-yellow (2.5 GY 7/8) and the leaf-sheath-covered stalk portions were yellow (5 Y 8/6). The buds of CP 05-1526 were ovate with emarginated basal wing region. The color of the buds on stalks of CP 05-1526 was yellow (5 Y 8/4) to green-yellow (2.5 GY 8/4). The leaf blade color on adaxial side, observed at the TVD leaves, was green-yellow (7.5 GY 4/4). The leaf midrib was white on the adaxial leaf side and green-yellow (5 GY 5/6) on the abaxial side. Leaf sheaths of CP 05-1526 adhered loosely to the stalk and had moderate to heavy pubescence. Auricles were completely absent on one side of CP 05-1526 and there were very few on the upper leaves above the fourth joint on the opposite side. The fourth dewlap below the TVD was narrow squarish with a moderate wax cover on the stalks. Dewlaps of CP 05-1526 were green-yellow (2.5 GY 7/10). Ligules were green-yellow (2.5 GY 7/2) and were broad crescent shaped.

Molecular Description

The six microsatellite primer pairs amplified 25 fragments, ranging from 105 to 258 bp, in CP 05-1526 (Table 2). The number of fragments amplified by each primer pair ranged from 3 to 7. Of the 25 fragments amplified, 18 were polymorphic and 7 were monomorphic. CP 05-1526 shared

Table 5. Botanical descriptions of sugarcane cultivar CP 05-1526 and reference cultivars CP 89-2143 as measured in field plantings on a muck soil at Eastgate Farm Inc. near Pahokee, FL and reference cultivar CP 78-1628 as measured in a field planting on a sand soil at United States Sugar Corporation Townsite Farm near Clewiston, FL.[†]

Trait[‡]	CP 05-1526	CP 89-2143	CP 78-1628
Stalk height (cm)	353	271	232
Stalk diameter (mm):			
Low	25.2	30.5	28.6
Middle	24.8	28.7	24.0
Upper	21.4	20.7	19.4
Leaf sheath pubescence	Moderate to heavy overall	Glabrous	Light, short along longitudinal center of sheath
Leaf length (cm)	140	177	201
Leaf width (cm)	4.84	3.99	4.03
Stalk bud shape	Ovate bud with emarginated basal wing region	Around bud with central germ pore	Narrow ovate bud with wing broadening toward apex
Stalk bud length (mm)	7.5	6.1	7.9
Stalk bud width (mm)	6.5	6.5	6.4
Auricle shape (long) and length (mm)	Very few, 7.6	Most present, 5.2	Few, 3.8
Internode shape	Cylindrical	Concave/convex	Conoidal
Internode length (cm)	14.9	11.8	18.1
Growth cracks	Few, length of internode and deep	Few, length of internode and shallow	Few, length of internode and moderate depth
Bud furrows	Few, extends 1/2–3/4 length of internode	Absent	Absent
Root band width (mm)	7.0	6.1	8.7
Growth ring width (mm)	2.7	2.3	3.2
Dewlap (leaf collar) shape	Narrow squarish	Narrow double crescent	Squarish deltoid, moderate wax cover
Ligule shape	Broad crescent	Crescent with lozenge	Crescent with lozenge

[†]Data are means of 10 stalks measured on 1 and 2 Aug. 2012.

[‡]Stalk diameters measured at the second (low), mean (middle) of the 5th and 10th, and topmost fully hardened (upper) internodes; internode length measured from the 5th node to the 6th node; bud width and length, root band width, and growth-ring width measured at the 5th node from the ground.

16 fragments with CP 78-1628, 18 with CP 72-2086, 10 with CP 89-2143, 18 with CP 80-1743, and 14 with CP 84-1198. Fragments unique to CP 05-1526 were identified in the fingerprints obtained using primer pairs SMC179SA (142 and 195 bp), SMC1493CL (159 bp) and mSSCIR53 (191 bp). *Bru*1 was not detected in CP 05-1526 (Table 6).

Disease Resistance

Based on natural infection and inoculation tests, CP 05-1526 was determined to be moderately resistant to brown rust in Florida although *Bru*1, a sugarcane brown rust resistance gene (Asnaghi et al., 2004), was not detected in the molecular test (Table 6). This result suggests that other genes may also be involved in the resistance of sugarcane plants to brown rust in addition to *Bru*1. CP 05-1526 is moderately resistant to orange rust. Like most other CP commercial cultivars in Florida, CP 05-1526 is susceptible to *Sugarcane yellow leaf virus*.

CP 05-1526 did not show symptoms of eye spot based on the field inoculation test in stage 2. Field inoculations with smut were also conducted during stages 3 and 4. CP 05-1526 had 0.4% plants with sori compared with a mean of 1.8% plants with sori for CP 73-1547 and 3.2% plants with sori for CP 78-1628. No sori were found in stage 4 on CP 05-1526 or CP 78-1628 as a result of natural infection. Based on these artificial inoculation and natural infection data, CP 05-1526 is considered to be moderately resistant to smut (Table 6).

Greenhouse inoculations were conducted with leaf scald and mosaic from 2008 to 2010. CP 05-1526 was compared with CP 80-1743 for the percentage of infected plants with leaf scald and compared with CP 72-2086 for the

Table 6. Disease reactions and presence (+) or absence (–) of the *Bru*1 gene in sugarcane cultivar CP 05-1526 and reference cultivars CP 72-2086, CP 78-1628, and CP 89-2143 in Florida.

Cultivar	Mosaic	Smut	Brown rust	*Bru*1	Orange rust	Leaf scald	Ratoon stunt	Sugarcane *yellow leaf virus*
CP 05-1526	R[†]	R	MR	–	MR	R	MR	S
CP 72-2086	S	R	MS	+	MS	R	R	S
CP 78-1628	R	S	S	–	R	MS	MS	S
CP 89-2143	MS	R	R	+	R	MS	MS	S

[†]R, resistant; MR, moderately resistant; MS, moderately susceptible; S, susceptible.

percentage of infected plants with mosaic. In all 3 yr of leaf scald inoculations, CP 05-1526 was substantially less infected than CP 80-1743 with 7.0, 6.1, and 0.0% plants infected in 2008, 2009, and 2010, respectively, compared with 37.8, 20.7, and 41.1% CP 80-1743 plants infected. CP 05-1526 showed no mosaic symptoms by artificial inoculation in 2008, 2009, and 2010; however, 66.4, 31.0, and 27.3% of the CP 72-2086 plants were infected in the same years, respectively. Throughout stages 3 and 4, no plants of CP 05-1526 were identified that were naturally infected with leaf scald or mosaic. Based on inoculated tests and natural infection, CP 05-1526 is considered to have sufficient resistance to leaf scald and mosaic for commercial production in Florida (Table 6). The 3-yr mean number of colonized vascular bundles of CP 05-1526 (6.1) was less than that for CP 72-1210 (12.3) and CP 80-1827 (8.2). Therefore, CP 05-1526 is considered resistant to ratoon stunt.

Freeze Tolerance

The sucrose deterioration on 6 Jan. 2012 (i.e., the percentage by which the sucrose concentration in juice declines compared with the sucrose concentration at the first sampling date on 9 Nov. 2011) ranged from 1.3 to 5.6% among the 22 tested genotypes with an average of 3.3%. Rankings from 1st to 22nd signified the best (lowest sucrose deterioration) to worst (highest deterioration) freeze tolerance. CP 05-1526 ranked 11th among the 22 genotypes on 6 Jan. 2012, and CP 72-2086, CP 78-1628, and CP 89-2143 ranked 10th, 7th, and 1st in freeze tolerance, respectively. At the last sampling date (9 Feb. 2012), an average of 64.4% (range from 42.9 to 87.5%) of sucrose was lost from juice among the genotypes, and CP 05-1526, CP 72-2086, CP 78-1628, and CP 89-2143 ranked 9th, 12th, 8th, and 1st, respectively. Based on these results, CP 05-1526 is considered to be much less tolerant to freezing than CP 89-2143 but is similar to CP 72-2086 and CP 78-1628.

Availability

In its initial year of release, seed cane of CP 05-1526 will be available from the Florida Sugar Cane League, Inc. for commercial planting in Florida. It is not anticipated that patent protection for CP 05-1526 will be sought. Small quantities of seed cane for research purposes may be obtained at the USDA-ARS Sugarcane Field Station, Canal Point, FL where CP 05-1526 will be maintained for at least 5 yr from the date of this publication.

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